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FINAL REPORT

Expanded Southern Pine Beetle Program

# Evaluation of Several Concentrations of Chlorpyrifos for Remedial and Preventive Control of Southern Pine Beetle, *Dendroctonus frontalis* Zimmerman

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## ABSTRACT

Three concentrations of chlorpyrifos were tested to determine their effectiveness in both the remedial and preventive aspects of southern pine beetle, Dendroctonus frontalis Zimmerman, control. Treatments were 0.5, 1.0 and 2.0 percent chlorpyrifos and 0.5 percent lindane as the standard. In addition, cloth residue analysis was conducted to determine the amount of chlorpyrifos that could rub off of treated bark onto clothing.

All treatments significantly reduced the number of beetles emerging from the bolts when compared to the control. For preventive control, 0.5 percent chlorpyrifos prevented attack for the first month and prevented gallery construction for three months. Lindane, 1.0 and 2.0 percent chlorpyrifos all prevented southern pine beetle attack for three months, and prevented gallery construction through seven months.

The residue analysis showed there was a noticeable reduction in the amount of chlorpyrifos available through contact with treated bark after the bark had dried.

## INTRODUCTION

Insecticides remain an important tool in pest management, yet until recently little had been done to refine insecticides for use against southern pine beetle, Dendroctonus frontalis Zimmerman, since the 1950's. For over 20 years benzene hexachloride (BHC) and lindane, the gamma isomer of BHC, have been the insecticides most commonly recommended and used for preventive and remedial control of southern pine beetle (Johnston, 1952; Hetrick and Moses, 1953). Other investigators continued to report their effectiveness in diesel oil (Gara and Vite', 1965; Anderson, 1967) and in water solution for summer control (Bennett and Pickard, 1966). However, these two chlorinated hydrocarbons are persistent in the environment, and are currently under review by the Environmental Protection Agency. Consequently, it has become necessary to consider other alternatives such as the organophosphates and the carbamates.

Tests involving organophosphates were reported by Lyon (1971) against the western pine beetle, Dendroctonus brevicomis LeConte, and Ragenovich and Coster (1974) reported testing organophosphates and carbamates on southern pine beetle and Ips spp.

Chlorpyrifos was one organophosphate that showed promise as an alternative to lindane against western pine beetle in contact toxicity studies (Lyon, 1971).

Smith, Trostle, and McCambridge (1977) reported that 2.0 percent chlorpyrifos in both diesel oil and water successfully prevented attacks by pine-bark beetles in ponderosa (Pinus ponderosa Lawson) and lodgepole (P. contorta Douglas) pines. Merkel (1977) and Hertel and Williams (1977), found both a 1.0 and 2.0 percent solution to be effective in preventing black turpentine beetle, Dendroctonus terebrans (Olivier), attacks in paraquat treated trees. In contact toxicity studies involving southern pine beetle adults, chlorpyrifos was more toxic than lindane (Hastings and Jones, 1976). Coster (1974, pers. comm.) reported that 1.0 and 2.0 percent aqueous solutions significantly reduced emergence of adult southern pine beetles from treated loblolly pine bolts.

This study was devoted to obtaining more extensive information on the effectiveness of chlorpyrifos on southern pine beetle.

## OBJECTIVES

The objectives of this study were (1) to compare the efficacy of recommended concentrations of chlorpyrifos for remedial and preventive control of the southern pine beetle on loblolly pine in the field, and (2) to determine chlorpryifos residues on bark surfaces.

## METHODS

I. Remedial Control: A completely randomized design was used involving five treatments and eight replications. Six replications were conducted with loblolly pine (Pinus taeda L.), and two replications were with shortleaf pine (P. echinata Mill). Treatments included 0.5 percent lindane as the standard, 0.5, 1.0 and 2.0 percent chlorpyrifos, and the control. Insecticides used were Lindane E-1[2/] with 12.5 percent gamma isomer of benzene hexachloride a.i. and Dursban 2E[2/] with 22.4 percent chlorpyrifos a.i. For later replications Dursban 4E with 41.2 percent a.i. was used.

Five trees were used in each replication with one treatment randomly assigned to each tree. Three one-meter bolts were cut from the lower, middle, and upper portions of the infested bole and marked for identification. Trees selected for each replication were of the same species with similar d.b.h. (approximately 15 cm.), and contained brood in the late larval and pupal stages.

The bolts were taken to the laboratory where one 100 $cm^2$ bark sample was taken from each end of the bolts with a hole saw attached to a power drill. The bolts were then cut to approximately 60 cm lengths

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2/ Thompson - Hayward Chemical Company

3/ Dow Chemical Company

and treated. Treatments were applied with a Hudson Model 6210 hand pump sprayer over the total surface area of the bolts to the point of runoff. Bolts were allowed to dry, then brought into the insectary where they were suspended from modified sawhorses by eye-bolts. A loose fitting 32-mesh saran sleeve was placed around each bolt and tied at both ends. Emerging beetles were counted every 24 hours whenever possible. When emergence had ceased, the bolts were taken down and length and diameter measured. Two more bark samples were taken from each bolt. All bark samples were x-rayed in a Faxitron® model 805 unit to determine both pre-spray and post-emergence populations. X-ray interpretation was done by the same individual to maintain consistency in interpretation.

II. Preventive Control: This aspect of the study involved a total of six replications using loblolly pine. Four replications were conducted in 1975. Four treatments were used and included, 1.0 and 2.0 percent chlorpyrifos, 0.5 percent lindane as a referent, and a control. The remaining two replications were conducted in 1976 and a fifth treatment, 0.5 percent chlorpyrifos was added to establish a lower limit of insecticide effectiveness.

Four groups of 12 trees, about 20 cm. d.b.h., were marked and treated in the summer of 1975. A 30 m buffer strip separated each group of trees to eliminate any effect from drift. Treatments were applied at 250 p.s.i. pressure using a Kelsco® sprayer (Figure 1) with a 3 h.p.

Briggs and Stratton motor, and equipped with a Spraying System Company Gunjet #2 nozzle attached to a 3/8" diameter hose. The bark of each tree was thoroughly sprayed from the base to the lower crown, or as high as the spray would effectively reach, approximately 7 meters.

The sprayed trees provided the bolts used in the replications. Each location or southern pine beetle spot was considered a replication. Spots were located on the Vernon, Evangeline and Catahoula Ranger Districts of the Kisatchie National Forest, Louisiana. Treatment trees were felled as needed and usually only two 2-meter bolts were taken from the bole of each tree. Bolts were tied to uninfested trees at the active head of a southern pine beetle spot, with the butt of the bolts about one and one half meters above the ground (Figure 2). Two sticky traps made of 12.5 x 20 cm (250 $cm^2$) screen coated with Stickem Special® or aerosol Tree Tanglefoot® and two vials containing one milliliter of frontalure[4/] each were attached to the bolt. Traps were checked at one week intervals and the numbers of beetles on both sides of the traps were counted, giving a total sample area of 500 $cm^2$ for each screen. Beetles were either removed or the traps replaced. The numbers of attacks on the bolts and the approximate number of attacks per square foot on the tree were also recorded. Every 30 days the bolts were taken down and new bolts were hung on uninfested trees at the head of the spot. A section was cut from each bolt when it was removed. At the laboratory, the bark was shaved off and the total gallery length measured. The length and diameter of the section of the bolt was also measured.

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4/ One part frontalin and two parts alpha-pinene.

Figure 1: Spraying system used for treating standing trees with chlorpyrifos in attack prevention study for southern pine beetle.

Figure 2: Treated bolts were tied to uninfested trees at the head of an active southern pine beetle spot; sticky traps and vials of frontalure were attached to the bolts to attract southern pine beetles to the bolts and monitor their arrival.

III. Residue Analysis: In order to determine the amount of insecticide that would rub off the bark and onto clothing, a simple cloth analysis test was done. Pieces of cotton cloth, 12 $cm^2$, were rubbed over the bark surface of treated trees for each treatment, as listed in Table 1. Samples were taken by firmly rubbing the cotton cloth over the treated bark surface immediately after spraying (wet) and 120 minutes after treatment (dry). Separated trees were treated for the residue analysis at the same time the trees for the preventive study were treated.

After samples were taken the cloth was folded several times with the contacted surface to the inside, tied and stored in a freezer. Samples were shipped to the University of Georgia[5/] for analysis. All samples were placed in large culture tubes and extracted with 40 ml. ETOAC for 48 hours. Then they were dried with $Na_2SO_4$ and appropriate dilutions were made. Analysis was made on a GLC - flame photometric detector using standard techniques.

IV. Data Analysis: A three-way analysis of variance for a completely randomized design was conducted for the remedial study. Treatment, location on the bole, and species were tested using adjusted emergence. Both a t-test for a contrast coefficient matrix and a Duncan's multiple range test were preformed to determine differences within treatments. The t-test was preformed to test the difference of 0.5, 1.0 and 2.0 percent chlorpyrifos when compared to the control or lindane. An

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5/ Dr. U. E. Brady, Department of Entomology.

Table 1: Schedule for collecting cloth residue samples through surface contact with chlorpyrifos treated bark.

| Treatment | No. of replications 1 unit area[1/] | 3 unit areas |
|---|---|---|
| 0.5% wet[2/] | 2 | 2 |
| 0.5% dry[3/] | 2 | 2 |
| 1.0% wet | 4 | 4 |
| 1.0% dry | 4 | 4 |
| 2.0% wet | 4 | 4 |
| 2.0% dry | 4 | 4 |
| Control | 3 | 3 |

1/ Unit area represents .09 $m^2$ or 1 sq. ft. surface area contacted.

2/ Wet - immdiately after treatment when bark is still wet.

3/ Dry - approximately 120 minutes after treatment when bark has dried.

arcsine transformation of brood reduction was also done on the numbers of brood within the disks before and after treatment.

Data analysis for the preventive treatment study involved an analysis for a factorial design with three factors - treatment, replicate (site), and set (time). Two factor ANOVAS were run for treatment and set, and treatment and replicate to determine which factors had a significant effect on the measured variables. Next, one-way ANOVAS were run on subsets of the data to evaluate the influence of time lags (sets) on each treatment, and the effect of treatments within each set. Duncan's multiple range test was used to provide means for each treatment on set variable and to detect differences between means.

## RESULTS AND DISCUSSION

I. Remedial Control: Analysis of variance of the emergence data from the treated bolts indicated that treatment effects were significant at the .05 confidence level. No other main effects were singificant; i.e. there was no difference in emergence from the location of the bolt or species of host. Table 2 shows the total numbers of beetles emerging from the treatment bolts and the average number of emerging beetles per .09 square meters of bark surface (see also Appendix; Table 1). In the t-test for treatment mean separation, contrasts were set up to test the difference between 0.5, 1.0 and 2.0 percent chlorpyrifos and the control and lindane. Contrasts were not tested among the chlorpyrifos treatments. The t-test showed there was a significant difference between each of the

Table 2: Summary of numbers of beetles per .09 $m^2$ (= 1 $ft^2$) before treatment and after emergence from bolts treated with various concentrations of chlorpyrifos for remedical control of southern pine beetle.

| Treatment | Total No. of emerging beetles | Avg. No. of brood per .09 $m^2$ (= 1 $ft^2$) before treatment | Avg. No. of emerging beetles per .09 $m^2$ (= 1 $ft^2$) | % of beetles emerging from treatments |
|---|---|---|---|---|
| Control | 9885 | 196 | 125 | 64 |
| Lindane | 2309 | 256 | 29 | 11 |
| Chlorpyrifos | | | | |
| 2.0% | 1565 | 263 | 21 | 8 |
| 1.0% | 1719 | 298 | 24 | 8 |
| 0.5% | 3275 | 221 | 46 | 21 |

concentrations of chlorpyrifos and the control; but no significant difference was found between any of the chlorpyrifos treatments and lindane. The Duncan's multiple range tested essentially the same comparisons, but also tested for any differences among the chlorpyrifos treatments. At the 0.5 confidence level all chemical treatments performed better than the control, but no chemical treatment was statistically better than any other chemical treatment. Figure 3 shows the average number of emerging beetles per .09 square meter of bark surface for each replication. Although there appeared to be variability in numbers of emerging populations, as seen in the control, replicating the experiment had taken this into account. Lindane, 1.0 and 2.0 percent chlorpyrifos gave a fairly consistent effect on emerging bark beetles; however, although statistically there is no significant difference in overall control between 0.5 percent and 1.0 and 2.0 percent chlorpyrifos and lindane, the graph suggests that there was variation in the consistency of 0.5 percent chlorpyrifos. Approximately twice as many beetles per unit area emerged from the 0.5 percent chlorpyrifos than from the 1.0 and 2.0 percent and lindane (Table 2).

The arcsine transformation showed no significant difference in brood reduction between treatments. In other words, the number of brood per unit area of bark surface before treatment was reduced proportionately after emergence in all treatments. The strength of this test is limited by several factors associated with the x-rays. For instance, timing of the x-rays or dead brood may result in a less than accurate picture of the

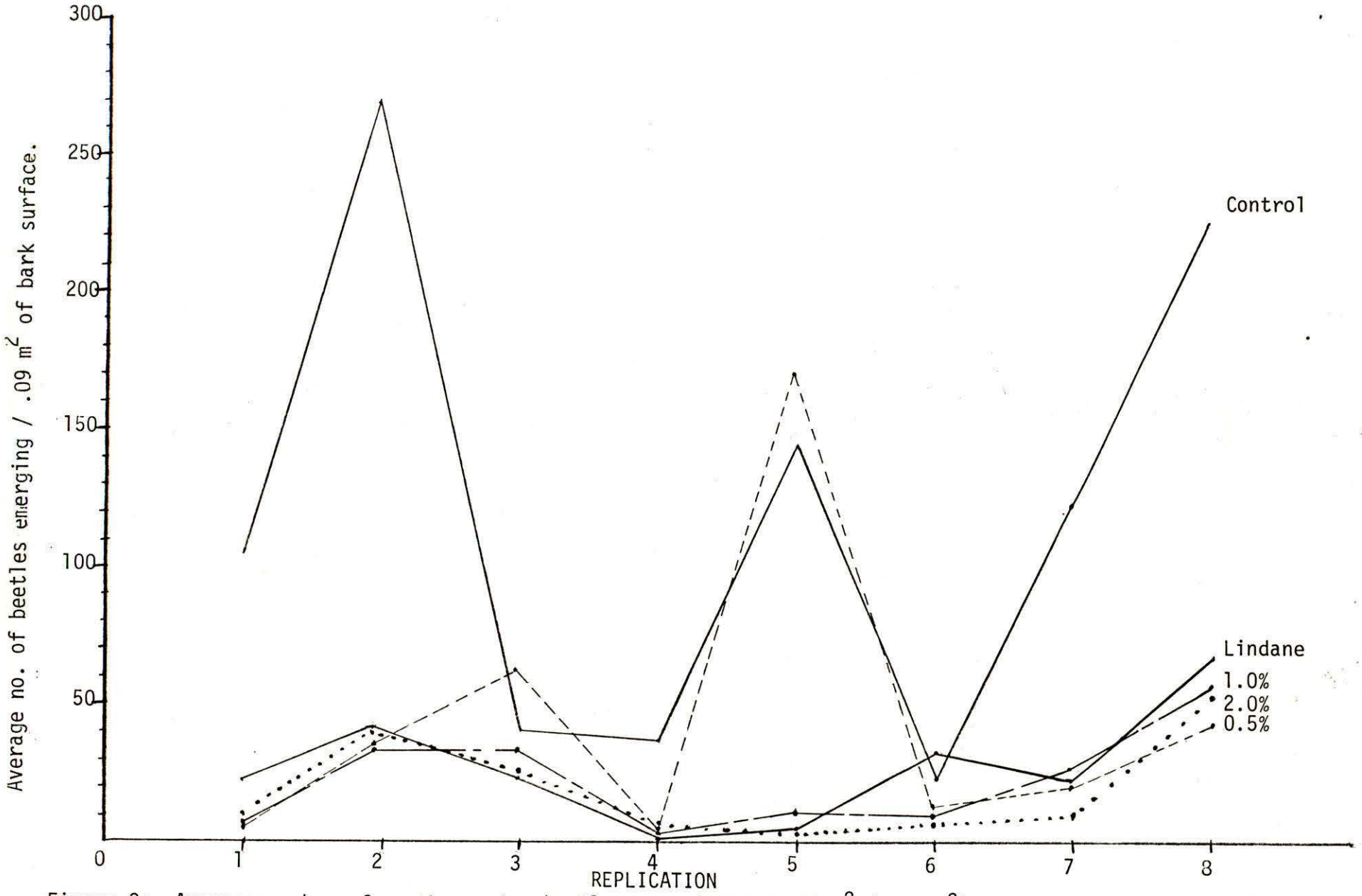


Figure 3: Average number of southern pine beetles emerging per .09 $m^2$ (= 1 $ft^2$) of bark surface from bolts treated with various concentrations of chlorpyrifos for remedial control.

beetle population. However, by using the x-rays to determine the average number of brood per unit area and dividing that into the average number of emerging beetles per unit area for each treatment, an estimated percentage of emerging beetle populations can be obtained. Table 2 shows there was a higher percent of emergence from the control than from any of the other treatments.

II. Preventive Control: Analyses for two-factor ANOVAS were run for three measured variables: 1) trap catch, 2) attacks on bolts, and 3) gallery length. Treatment and set (time), and treatment and replication (site) were the two-factor ANOVAS considered. The treatment effect for all variables in both ANOVAS was significant. In the ANOVA for treatment X set (time) the only variable which showed a significant interaction between factors was the adjusted attack variable. This implies there was a different treatment effect at different times after application, i.e. there is a change in response with time. There was a significant difference between sets for the trap catch variable, however, no significant interaction suggests that the changes in trap catch were associated with population densities over time and not with the age of the insecticide. In both the treatment X set (time) and the treatment X replication (site) analysis, the variation in population densities over time and the variation between sites did not influence the action of the insecticides with respect to any of the measured variables.

One way ANOVAS were conducted to determine the effect of time on the ability of the treatments to prevent attack. Analysis was done for seven months data. The trap catch variable was mainly used to determine the presence of southern pine beetle. There were no significant differences in the numbers of beetles coming to each treatment over the time span tested. Equal numbers of beetles were available to attack each treatment. The attack and gallery length variables were a measure of treatment effect. There were no significant differences between lindane, 1.0 and 2.0 percent chlorpyrifos in ability to prevent attack for up to three months. After three months there was no significant difference between treatments in ability to prevent attack. The 0.5 percent chlorpyrifos prevented attack for the first month only; after that there was no significant difference between it and the control in ability to prevent attack.

In terms of gallery length, the lindane, 1.0 and 2.0 percent chlorpyrifos provided significant protection for the seven months of the test. The 0.5 percent chlorpyrifos prevented gallery construction for three months. This indicates that the 0.5 percent chlorpyrifos was able to prevent attacks for only the first month, but was able to prevent gallery construction for three months. Apparently, the beetles were able to initiate attack and begin boring into the bark before being affected by the insecticide after the first month. The lindane, 1.0 and 2.0 percent chlorpyrifos were able to prevent initial attack for up to three months, and gallery construction for seven months.

III. Residue Analysis: Table 3 shows the results of the cloth residue analysis. As would be expected the mg of chlorpyrifos per unit area of bark contacted increased as the concentration of the insecticide increased when the bark was freshly treated. There was a noticeable decrease in the amount of chlorpyrifos available through contact with the treated bark after the bark had dried. Tables 2 and 3 in the Appendix show the lab results for the analysis.

## CONCLUSIONS

Results of this study show that for remedial control all treatments were significantly better than the control. There was no significant difference between lindane, 0.5, 1.0 and 2.0 percent chlorpyrifos in reducing numbers of emerging beetles from treated bolts. However, raw data shows that approximately twice as many beetles per square foot emerged from the 0.5 percent chlorpyrifos treated bolts as from the lindane, 1.0 and 2.0 percent chlorpyrifos treated bolts.

For preventive control the results show that 0.5 percent chlorpyrifos prevented attack for one month and gallery construction for three months. Lindane, 1.0 and 2.0 percent chlorpyrifos prevented attack for three months and gallery construction through seven months.

The residue analysis showed there was a noticeable reduction in the amount of chlorpyrifos available through contact with treated bark after the bark had dried.

Table 3: Results of cloth residue analysis for chlorpyrifos reported as mg/.09 $m^2$ (= 1 $ft^2$) bark contacted[1/]

| Treatment | (wet) | (dry) |
|---|---|---|
| 2.0% Chlorpyrifos (1) | 53.20 | 1.69 |
| (3) | 27.34 | 0.97 |
| 1.0% Chlorpyrifos (1) | 16.40 | 1.81 |
| (3) | 10.20 | 1.44 |
| 0.5%[2/] Chlorpyrifos (1) | 3.60 | 0.92 |
| (3) | 1.87 | 0.45 |

1/ Number in parenthesis represents units of area (.09 $m^2$) of bark contacted. Residue is reported as mg/unit area, therefore, residue for 3 units contacted is not total mg of residue in cloth sample.

2/ Averages based on only 2 replications.

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This paper reports findings for a study involving pesticides. It does not contain recommendations for their use, nor does it imply the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

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## PROGRAM SUPPORTED ACTIVITIES

1. Publications - none.

2. Meetings - First Annual ESPBRAP meeting in New Orleans, Louisiana November 5-6, 1975.

   Toxicant subgroup meeting in Atlanta, Georgia, February 10, 1975.

   Toxicant group meeting in New Orleans, Louisiana January 10-11, 1977.

3. Personnel supported by program funds - temporary technician four month appointment; temporary technician - 180-day appointment.

   Cooperators related to project:

   Dow Chemical Company
   Kisatchie National Forest - Catahoula, Evangeline and Vernon Ranger Districts.

4. Cooperation with others:

   F. L. Hastings and A. S. Jones, Southeastern Forest Experiment Station, Research Triangle Park, N. C.

   C. W. Berisford and V. E. Brady - University of Georgia

   W. W. Neel, G. Fitzpatrick and J. Lashomb - Mississippi State University.

# APPENDIX

Table 1. Summary of data on number of emerging beetles for testing the effect of various concentrations of chlorpyrifos for remedial control of southern pine beetle in Louisiana.

| Treatment | Replication 1 No. beetles emerging | Replication 2 No. beetles emerging | Replication 3 No. beetles emerging |
|---|---|---|---|
| Control top | 204 | 757 | 35 |
| middle | 239 | 1198 | 123 |
| bottom | 380 | 1188 | 112 |
| Total | 828 | 3143 | 270 |
| $\bar{X}$ No. of beetles emerging/unit area[1/] | 109.44 | 269.32 | 44.12 |
| Lindane top | 21 | 73 | 89 |
| middle | 68 | 128 | 46 |
| bottom | 57 | 107 | 69 |
| Total | 146 | 308 | 204 |
| $\bar{X}$ No. of beetles emerging/unit area | 21.95 | 43.32 | 28.22 |
| Chlorpyrifos 2.0% top | 2 | 69 | 35 |
| middle | 18 | 158 | 112 |
| bottom | 49 | 91 | 120 |
| Total | 69 | 318 | 267 |
| $\bar{X}$ No. of beetles emerging/unit area | 9.29 | 42.74 | 29.60 |
| Chlorpyrifos 1.0% top | 11 | 63 | 81 |
| middle | 44 | 79 | 42 |
| bottom | 5 | 95 | 87 |
| Total | 60 | 237 | 210 |
| $\bar{X}$ No. of beetles emerging/unit area | 7.94 | 32.16 | 36.78 |
| Chlorpyrifos 0.5% top | 14 | 71 | 60 |
| middle | 23 | 188 | 122 |
| bottom | 11 | 61 | 181 |
| Total | 48 | 320 | 363 |
| $\bar{X}$ No. of beetles emerging/unit area | 7.37 | 35.05 | 65.29 |

1/ Unit area equivalent to .09 $m^2$ (= 1 $ft^2$).

Table 1: (Continued)

| Treatment | Replication 4 No. beetles emerging | Replication 5 No. beetles emerging | Replication 6 No. beetles emerging |
|---|---|---|---|
| Control top | 58 | 545 | 119 |
| middle | 147 | 591 | 106 |
| bottom | 114 | 402 | 40 |
| Total | 319 | 1538 | 265 |
| $\bar{X}$ No. of beetles emerging/unit area | 43.46 | 147.04 | 26.88 |
| Lindane top | 3 | 27 | 184 |
| middle | 6 | 13 | 229 |
| bottom | 2 | 15 | 30 |
| Total | 11 | 55 | 443 |
| $\bar{X}$ No. of beetles emerging/unit area | 1.31 | 5.86 | 36.02 |
| Chlorpyrifos top 2.0% middle | 5 | 27 | 8 |
| | 23 | 19 | 15 |
| bottom | 1 | 11 | 34 |
| Total | 29 | 57 | 57 |
| $\bar{X}$ No. of beetles emerging/unit area | 9.86 | 4.35 | 6.09 |
| Chlorpyrifos top 1.0% middle | 8 | 49 | 33 |
| | 15 | 48 | 29 |
| bottom | 27 | 37 | 29 |
| Total | 50 | 134 | 91 |
| $\bar{X}$ No. of beetles emerging/unit area | 6.00 | 13.12 | 8.40 |
| Chlorpyrifos top 0.5% middle | 2 | 629 | 33 |
| | 6 | 765 | 73 |
| bottom | 64 | 44 | 45 |
| Total | 72 | 1438 | 151 |
| $\bar{X}$ No. of beetles emerging/unit area | 7.87 | 170.38 | 12.87 |

Table 1: (Continued)

| Treatment | Replication 7 No. beetles emerging | Replication 8 No. beetles emerging | Total |
|---|---|---|---|
| Control top | 258 | 546 | 2522 |
| middle | 496 | 655 | 3555 |
| bottom | 557 | 1015 | 3808 |
| Total | 1311 | 2216 | 9885 |
| $\bar{X}$ No. beetles emerging/unit area | 132.42 | 227.28 | 125.00 |
| Lindane top | 98 | 70 | 565 |
| middle | 72 | 124 | 686 |
| bottom | 77 | 701 | 1058 |
| Total | 247 | 895 | 2309 |
| $\bar{X}$ No. beetles emerging/unit area | 26.91 | 72.24 | 29.48 |
| Chlorpyrifos top | 23 | 309 | 478 |
| 2.0% middle | 22 | 205 | 572 |
| bottom | 31 | 178 | 515 |
| Total | 76 | 692 | 1565 |
| $\bar{X}$ No. of beetles emerging/unit area | 6.83 | 55.76 | 20.57 |
| Chlorpyrifos top | 63 | 170 | 478 |
| 1.0% middle | 129 | 231 | 617 |
| bottom | 100 | 244 | 624 |
| Total | 292 | 645 | 1719 |
| $\bar{X}$ No. beetles emerging/unit area | 31.67 | 57.85 | 24.24 |
| Chlorpyrifos top | 53 | 170 | 1032 |
| 0.5% middle | 122 | 231 | 1530 |
| bottom | 63 | 244 | 713 |
| Total | 238 | 645 | 3275 |
| $\bar{X}$ Nol beetles emerging/unit area | 25.56 | 46.24 | 46.33 |

Table 3: Results of anlysis of cloth residue samples for chlorpyrifos (Dursban 2E) treatment applied August 1975.

| Sample | pk. ht. (mm) | Conc. (ng/5 µl) | Dilution | mg Dursban |
|---|---|---|---|---|
| 1% D-1 1/ | 34 | 4.5 | 1:50 | 1.80 |
| | 16 | 2.2 | 1:50 | 0.88 |
| 1% D-3 | 66 | 8.6 | 1:100 | 6.88 |
| | 42 | 5.5 | 1:100 | 4.40 |
| 2% D-1 | 10 | 1.4 | 1:50 | 0.56 |
| | 18 | 2.4 | 1:50 | 0.96 |
| 2% D-3 | 20 | 2.7 | 1:100 | 2.16 |
| | 17 | 2.3 | 1:100 | 1.84 |
| 1% W-1 | 17 | 2.3 | 1:1000 | 18.4 |
| | 18 | 2.4 | 1:1000 | 19.2 |
| 1% W-3 | 24 | 3.2 | 1:1000 | 25.6 |
| | 29 | 3.8 | 1:1000 | 30.4 |
| 2% W-1 | 83 | 10.8 | 1:1000 | 86.4 |
| | 54 | 7.1 | 1:1000 | 56.8 |
| 2% W-3 | 100 | 13.0 | 1:1000 | 104.0 |
| | 68 | 8.9 | 1:1000 | 71.2 |
| Control 1 | 58 | 7.6 | N.D. | .061 |
| 2 | 61 | 8.0 | N.D. | .064 |
| 3 | 75 | 9.3 | N.D. | .074 |

1/ D = dry bark surface
W = wet bark surface
1 = 1 unit area bark surface contacted
3 - 3 unit areas bark surface contacted

Table 2: Results of analysis of cloth residue samples for chlorpyrifos (Dursban 4E) treatment applied April 1976.

| Sample | pk. ht. (mm) | Conc. (Ng/5 µl) | Dilution | mg Dursban |
|---|---|---|---|---|
| 0.5% D-1 1/ | 18 | 1.9 | 1:50 | .76 |
| | 25 | 2.7 | 1:50 | 1.08 |
| 0.5% D-3 | 35 | 3.8 | 1:50 | 1.52 |
| | 28 | 3.0 | 1:50 | 1.20 |
| 1.0% D-1 | 43 | 4.7 | 1:50 | 1.88 |
| | 61 | 6.7 | 1:50 | 2.68 |
| 1.0% D-3 | 76 | 8.4 | 1:50 | 3.36 |
| | 62 | 6.8 | 1:50 | 2.72 |
| 2.0% D-1 | 51 | 5.6 | 1:50 | 2.24 |
| | 68 | 7.5 | 1:50 | 3.00 |
| 2.0% D-3 | 85 | 9.5 | 1:50 | 3.80 |
| | 87 | 9.7 | 1:50 | 3.88 |
| 0.5% W-1 | 16 | 0.8 | 1:500 | 3.2 |
| | 22 | 1.0 | 1:500 | 4.0 |
| 0.5% W-3 | 20 | 0.9 | 1:1000 | 7.2 |
| | 12 | 0.5 | 1:1000 | 4.0 |
| 1.0% W-1 | 57 | 2.6 | 1:1000 | 20.8 |
| | 20 | 0.9 | 1:1000 | 7.2 |
| 1.0% W-3 | 82 | 3.5 | 1:1000 | 28.0 |
| | 112 | 4.8 | 1:1000 | 38.4 |
| 2.0% W-1 | 152 | 7.1 | 1:1000 | 56.8 |
| | 75 | 3.2 | 1:1000 | 25.6 |
| 2.0% W-3 | 162 | 7.7 | 1:1000 | 61.6 |
| | 130 | 5.7 | 1:2000 | 91.2 |

1/ D = dry bark surface
W = wet bark surface
1 = 1 unit area bark surface contacted
3 = 3 unit areas bark surface contacted